

PACIFIC SPECIES OF GALAXAURA

I. ASEXUAL TYPES *

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THE genus *Galaxaura*, comprising calcified members of the Chaetangiaceae (Rhodophyceae), is morphologically of great interest to the botanist, although economically unimportant. The first specimens that were scientifically described were treated as polyps by Ellis and Solander (1786), under the name *Corallina* — a genus which, when first established by Linnaeus, contained all polyp-like animals and plants, but which is now entirely limited to a restricted genus *Corallina*, a group of calcareous red algae. After Ellis and Solander all naturalists working with the polyps adopted their classification, with the exception of Gmelin (1788) and Esper (1830), who put some of the species with *Tubularia*, which, in modern literature, is an animal genus of Hydrozoa (Coelenterata). In 1812 Lamouroux properly evaluated these so-called “polyps” as at least a distinct genus in a newly established family Corallineae, which included several genera of coralline algae. Nevertheless, like his contemporaries, he was not ready to give up the idea that these plants were animals, and so he regarded his family Corallineae as made up of “polypiers phytoides,” or plantlike polyps.

For over three years I have given much time to a taxonomic study of the genus, hoping to bring together all these marine plants and their descriptions for a revision. Unfortunately, the spread of the war throughout the areas inhabited by them has made them unavailable and rendered it impossible to obtain additional working material or to borrow type specimens. Consequently, the intended scope of research has been narrowed down to include only the Pacific species of *Galaxaura*.

This investigation covers the *Galaxaura* flora of both the west and the east sides of the Pacific basin. A collection from the Philip-

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pine Islands made by Professor H. H. Bartlett in 1935, together with collections from Java and Sumatra by Kostermans in 1938, typifies the *Galaxaura* flora of the western part of the tropical Pacific Ocean. Professor W. R. Taylor's specimens, secured by him on the Hancock Expedition in the years 1934 and 1939, are representative of the flora found along the eastern part of the tropical Pacific Ocean. In the materials from these two sources are eleven asexual species, including three new ones, and ten sexual species, with one new. To both gentlemen I am much indebted for furnishing materials for this investigation and for reviewing the manuscript. Special thanks are due to Professor Taylor for his critical guidance throughout the course of this study and to Professor Bartlett for other assistance. I am deeply grateful to the Levi Barbour Oriental Girls' Scholarship Fund of the University of Michigan, under which part of the research was carried on.

The plants of the genus *Galaxaura* are widely distributed in tropical and subtropical waters. They occur in the latitudes between 40° N. and 40° S. — northward as far as Japan and southward to Australia and the Cape of Good Hope, Africa.

The taxonomy of these plants is very incompletely known because the species within each division lack clear, definite differentiating features. Some plants may look identical in gross habit, but be entirely different in their cellular structure, as are members of the sections *Arboreae* and *Vepreculae*. Others may vary externally, but be similar in their structural organization, for example, *G. barbata* and the flattened species of the *Arboreae* or plants in the *Oblongatae* section.

The taxonomy is further complicated by the sexual dimorphism of the plants, first adequately demonstrated by M. A. Howe (1916, 1918). It is quite probable that the species are only half as numerous as the specific names hitherto proposed, but because of dimorphism each plant has received two names — one for the asexual and one for the sexual generation of the life cycle. The exact correspondence between the presumed alternate generations cannot be settled for individual species without comprehensive studies in the field with this point in view, or else without cultural studies. It cannot be settled by a comparison of herbarium specimens. In view of this fact the plants have had to be arbitrarily separated into sexual and asexual groups of nominal species. Each recognizable assemblage

of morphologically distinct plants is treated as an independent individual while we are awaiting recognition of the other phase in the life cycle. Whenever pairing is plausible it is mentioned in the discussions; Howe's hypothesis of sexual dimorphism is therefore tested so far as possible with herbarium materials.

In the *Galaxaurae*, because of the uncertainties of their life history, no attempt is here made toward the interpretation of the synonymy. All the species hitherto established, some doubtful as they may be, are maintained, and the identification of the plants on hand depends entirely on how closely they fit the type descriptions.

This paper (Part I of the whole study) deals with the asexual types only; the sexual plants will be treated in Part II, to appear in a later publication, which will complete the record of the Pacific species of *Galaxaura*.

NOMENCLATURE OF THE SECTIONS

It is to be regretted that Kjellman did not pay very much attention to the choice of sectional names when he wrote his monograph on *Galaxaura*. Of the sectional names used by him some are in correct form, as recommended by the International Rules, i.e. adjectives (preferably taken from representative or best-known species) in the plural, but other coördinate names are such as would be proper for subgenera, namely, substantives in the singular. Not only is it objectionable to have these two types of names used for coördinate generic subdivisions of the same category, but it is not appropriate to intersperse with them, as Kjellman did, some Latin adjectives used in the singular as substantives and others in the plural, apparently in the neuter gender instead of the feminine, as they would have to be in the genus *Galaxaura*.

I therefore propose certain modifications of Kjellman's sectional names, with the understanding that such names as *Rhodura* and *Microthoë* would be available for consideration as retained subgeneric names in a natural classification based upon characteristics of both the sexual and the nonsexual phases of the species. The emended list of sections is as follows:

Subverticillatae for *Rhodura*
Squalidae for *Microthoë*
Oblongatae for *Eugalaxaura*
Arboreae for *Brachycladia*

Vepreculae (no change)
 Angustifrones for Laevifrons
 Robustae for Dichotomaria Cameratae
 Umbellatae for Dichotomaria Spissae

It is to be noted that the type or standard species of Galaxaura is *G. umbellata*. This species must therefore be included in any subgenus named Eugalaxaura, if the rules and ordinary usage are to be followed. Kjellman's classification does not include *G. umbellata* in his section Eugalaxaura, and so it is necessary to suppress his subgenus by this name; reconstituting it with the type included would only cause confusion.

KEY TO THE SPECIES OF GALAXAURA

ASEXUAL TYPES

Plants asexual or tetrasporic; branches terete throughout or flattened above, villous or glabrous; short assimilatory filament either of the type of the Subver-

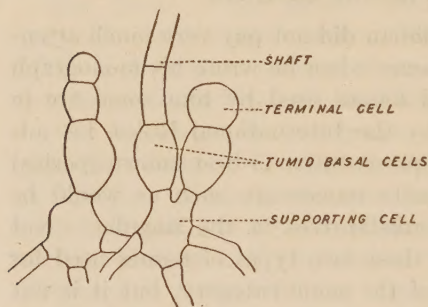


FIG. 1. Type of the Subverticillatae

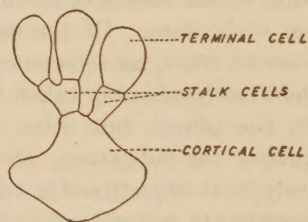


FIG. 2. Type of the Arboreae

ticillatae (Fig. 1), composed of a tumid basal cell and one or two terminal cells, or of the type of the Arboreae (Fig. 2), composed of stalk and terminal cells.

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|--|--------------------------------------|
| 1. Plants with branches terete throughout | 2 |
| 1. Plants with branches flattened above, although terete below
(Section Arboreae) | 8 |
| 2. Branches glabrous, robust, 2-4 mm. thick; segments turgid, articulate,
or subarticulate | (Section Robustae) <i>G. robusta</i> |
| 2. Branches villous or hirsute, bearing extended assimilatory filaments;
slender, not over 2 mm. in diameter | (Section Subverticillatae) 3 |
| 3. Assimilatory portion homogeneously filamentous, composed only of
extended assimilatory filaments; supporting cells undifferentiated;
tumid basal cells absent | <i>G. filamentosa</i> |
| 3. Assimilatory portion heterogeneous, composed of both extended and
short assimilatory filaments; supporting and tumid basal cells present | 4 |

4. Short assimilatory filaments of the type of the Arboreae (Fig. 2); extended filaments verticillate at base of each proliferation *G. barbata*
4. Short assimilatory filaments of the type of the Subverticillatae (Fig. 1); extended assimilatory filaments all over the thallus 5
5. Terminal cells of short assimilatory filaments wider than basal cells; both extended and short assimilatory filaments fasciculate *G. fasciculata*
5. Terminal cells of short assimilatory filaments subequal or narrower than basal cells; short and extended assimilatory filaments not fasciculate 6
6. Short assimilatory filaments predominantly two-celled, rarely three-celled *G. ramulosa*
6. Short assimilatory filaments commonly three-celled, some two-celled ... 7
7. Short and extended assimilatory filaments subverticillate; terminal cells of short assimilators smaller, narrower than basal cells .. *G. subverticillata*
7. Short assimilatory filaments few, evenly scattered among the extended ones; terminal cells variable, subequal, narrower, or wider than basal cells *G. subfruticulosa*
8. Cortical tissue 20–60 μ thick, 1–2-stromatic 9
8. Cortical tissue 60–80 μ thick, 2–3-stromatic *G. spathulata*
9. Thallus 2.0–3.5 mm. wide, angles wide; terminal cells of the short assimilators often apiculate *G. apiculata*
9. Thallus 1–2 mm. wide, angles round or acute; terminal cells of the short assimilators round or acute 10
10. Branches continuous, proliferations few *G. arborea*
10. Branches proliferous, constricted, or subarticulate; upper parts sometimes continuous; proliferations at the base surrounded by tufts of extended assimilatory filaments *G. stipitaulis*

***Galaxaura filamentosa*, sp. nov. — Pl. I,**

Figs. 1–6; Pl. VI, Fig. 1

"*Galaxaura rudis* Kjellm." as misidentified by Tanaka, 1936, p. 145, figs. 1–2; pl. 34, fig. 1; Tseng, 1941, pp. 85–86, fig. 1.

Planta 3.5–5 cm. alta ad substratum disco adfixa, frondibus teretibus cum filamentis assimilatoriis dense vestitis; dichotome ramosis vel interpositione rami adventivi ut videtur trichotome ramosis; internodiis 2–10 mm. longis, 0.5–1.5 mm. crassis (filamentis liberis haud inclusis); thallo ex filamentis in parte media intertextis, in parte exteriori parallelis constato sed structura homogeneo sine cortice; filamentis axialibus 16–24 μ diam., apice in filamenta assimilatoria chromatophoria transeuntibus per cellulas sustinentes non aut raro maleque differentiatas; absque cellulis basalibus tumidis; parte filamentorum assimilatoriorum libera 1–4.5 mm. longa, simpliciter vel irregulariter ramosa, ex cellulis cylindricis constante inferioribus 16–18 μ diam., et superioribus 20–22 μ diam., sesquiplo vel triplo

longioribus quam crassioribus. Specimen typicum legit W. R. Taylor, no. 39-46, in republica Mexicana, in loco dicto Sulphur Bay, Clarion I., Revilla Gigedo Ins., Mar., 1939; in herb. "Hancock Foundation," Univ. South. Calif.; duplum in herb. Univ. Mich.

Plants bushy, 3.5-5.0 cm. high, attached by a small discoid hold-fast; fronds terete, throughout densely covered by extended assimilatory filaments; branching more or less dichotomous, sometimes appearing trichotomous by development of adventitious branches; internodes 2-10 mm. long, 0.5-1.5 mm. thick (excluding extended filaments); thallus structurally filamentous, homogeneous, without differentiation of medullary and cortical layers; axial filaments 16-24 μ in diameter, their free ends extended into assimilatory chromatophore-bearing filaments with poorly developed or undifferentiated supporting cells; tumid basal cells totally absent; shaft of the assimilatory filaments 1.0-4.5 mm. long, simple or branched, composed of cylindrical cells, basal part 16-18 μ in diameter, the upper 20-22 μ in diameter, the length of individual cell 1.5-3 times as long as the diameter.

This new species is anatomically simpler than all the Subverticillatae hitherto described. Phylogenetically it may be closely related to Kjellman's *G. rudis* from the vicinity of Tonga, under which name the plants have undoubtedly been reported. The present investigation, however, shows that the assimilatory filaments of the Mexican and the Ecuadorian plants have only poorly developed or undifferentiated supporting cells, and the tumid basal cells, which are prominent in all other species, are entirely absent; thus the thallus is homogeneously filamentous throughout, with no differentiation between medullary and cortical tissues. Because of this I have considered these plants from the northern Pacific waters distinct from *G. rudis* of the southern Pacific; the latter species is clearly illustrated and described by Kjellman as having well-developed supporting and tumid basal cells.

Tanaka (1936) and Tseng (1941) reported the collecting of *G. rudis* in Formosa and on Hainan Island, respectively. Both authors have stated that their plants differ from Kjellman's *G. rudis* of the southern Pacific in having undifferentiated tumid and supporting cells. Therefore I am strongly inclined to think that the Chinese and the Formosan plants are identical with the Mexican and the Ecuadorian plants, or, at least, are distinct from *G. rudis*.

Specimens studied. — MEXICO: Sulphur Bay, Clarion Island, Revilla Gigedo Isands, *Taylor 39-46* (TYPE), March 17, 1939; COSTA RICA: Golfo Dulce, *Taylor 39-93*, March 26, 1939; Port Culebra, *Taylor 34-533*, Feb. 24, 1934; ECUADOR: Isabela Island, Archipelago de Colon, *Taylor 34-110*, Jan. 12, 1934.

Further distribution. — Formosa, Hainan Island.

***Galaxaura subfruticulosa*, sp. nov. — Pl. II,**

Fig. 6; Pl. VIII, Fig. 2

Kjellman, 1900, pp. 51-53, pl. 4, figs. 4-16, pl. 20, [fig. 19; (probably) Tanaka, 1936, p. 148, figs. 7-8, pl. 35, fig. 2; Tseng, 1941, pp. 87-92, fig. 3.

Plantae 5-6 cm. altae, ad substratum disco crasso adfixae; ramis villosis, saepe irregulariter dichotomis; internodiis 3-12 mm. longitudine; filamentis assimilatoriis aequaliter densis in omnibus thalli partibus; brevibus in partibus vetustioribus, longioribus interdum subverticillatis in partibus apicalibus et in basi proliferationum, longitudine plerumque minus quam 1 mm.; proliferationibus solitariis ad basim depressionum cupuliformium insertis; filamentis medulariis 6-18 μ , raro 24 μ , diam.; filamentis peripheralibus ex cellulis sustentibus plerumque male differentiatas etiamque cellulis assimilatorum basalibus tumidis ovoideis vel pyriformibus 45-65 μ longis, 28-40 μ crassis constantibus; brevibus filamentis assimilatoriis paucis, inter alia extensa dispersis, 2-cellulis vel 3-cellulis; cellulis terminalibus subglobosis, 20-34 μ diam., interdum paululo angustioribus quam cellulis subterminalibus atque basalibus; parte filamenti assimilatorii libera simplici vel raro ramosa, basi 14-16 μ diam., superne 16-18 μ diam.; cellulis duplo vel triplo longioribus quam crassioribus. Specimen typicum legit W. R. Taylor, no. 34-53, in republica Mexicana, in loco dicto Sulphur Bay, Clarion I., Revilla Gigedo Ins., Jan., 1934; in herb. "Hancock Foundation," Univ. South. Calif.; duplum in herb. Univ. Mich.

Plants 5-6 cm. high; attached to substratum by a broad discoid holdfast; branches villous throughout, often less regularly dichotomous; internodes 3-12 mm. long; the extended assimilatory filaments evenly distributed over the entire surface of the thallus, short on the older parts of the branches, longer and sometimes appearing subverticillate at the apex of the branches and at the base of proliferations, rarely attaining a length of 1 mm.; proliferations singly

emitted, base cupuliform; medullary filaments 6–18 μ , rarely to 24 μ in diameter, peripheral tissue consisting of supporting and tumid basal cells of the assimilators, the former commonly not well developed; tumid basal cells oval or pyriform, 45–65 μ long, 28–40 μ in diameter; short assimilatory filaments few, scattered among the extended ones, either two- or three-celled, terminal cells subglobose, 20–34 μ in diameter, equaling or slightly narrower than the subterminal and basal cells; shaft of the extended assimilatory filaments simple, occasionally branched, the basal part 14–16 μ in diameter, 16–18 μ above, cells 2–3 times as long as diameter.

These plants from Mexico have offered a real problem in the determination of the species. They share some characteristics with several members of the Subverticillatae, exhibiting no particularly distinctive traits, and still do not coincide satisfactorily with any known species.

In habit the thallus is villous, with the extended assimilatory filaments evenly distributed as in *G. ramulosa*, although the villi of the Mexican plants are not so long as those of *G. ramulosa*. The short assimilatory filaments, which are commonly few, are scantily scattered among the numerous extended assimilatory filaments. They are either two- or three-celled; when two-celled, they resemble the short assimilatory filaments of *G. ramulosa*; when three-celled, those of *G. subverticillata*, except that the terminal cells are subequal or slightly narrower than the subterminal and the basal cells, but not always so narrow as those of *G. subverticillata*. Furthermore, it is not uncommon to find the tumid basal cells bearing lateral branches for terminal cells, and rhizoidal or stoloniferous filaments connecting with adjacent cells or the medullary filaments — a characteristic distinctly exemplified in *G. fasciculata*. All these “mimetic” features complicate the sure determination of the species.

G. subfruticulosa may also be more or less closely related to Kützing's *G. tomentosa* from the east coast of Mexico, a species to which I was tempted to refer the present plants from the west coast of Mexico. Kützing's illustration in *Tabulae phycologicae*, Vol. VIII, p. 38, fig. 2, quite evidently shows that *G. tomentosa* does not have any short assimilatory filaments. All the assimilators are long and are composed of moniliform cells, with those near the basal part larger and the filament tapering gradually upward. It is, therefore, quite different from *G. subfruticulosa*.

Again, I was inclined to consider these plants identical with a Japanese species which has been called "*G. fruticulosa* Kjellm." because they agree with that species more closely than with other species of the Subverticillatae. As the studies proceeded, however, I discovered that *G. fruticulosa* was not first established by Kjellman at all, but, rather, is a name given by Lamouroux (1816) to Ellis and Solander's *Corallina fruticulosa* from the Bahama Islands. Curiously enough, whether through an oversight or a typographical error, Kjellman, in describing a Japanese plant, also called it *G. fruticulosa*, adding his own name as the specific authority. In the monograph he disregarded Lamouroux's early *G. fruticulosa* of the Bahama Islands, although, of course, he was familiar with and cited both Ellis and Solander's and Lamouroux's works. Furthermore, Lamouroux's *G. fruticulosa* was originally correctly cited by De Toni in *Sylloge algarum* (Vol. IV, Sectio I, p. 115. 1897). De Toni's work was also cited by Kjellman, so that it is almost unexplainable how he could have neglected the priority of the Bahaman species. This mistake of entirely disregarding the presumably valid early *G. fruticulosa* Lamouroux of the Bahamas and maintaining the distinct Japanese plant under the homonym *G. fruticulosa* Kjellman was made originally by Svedelius (1911), and later in De Toni's *Sylloge algarum*, Sectio V, Additamenta, 1924. The error has been repeated in recent publications, by Tanaka in 1936 and by Tseng in 1941. Regardless of whether or not the Japanese plant under the name "*G. fruticulosa* Kjellm." is identical with the Bahaman plant, the correct citation for the name is *Galaxaura fruticulosa* (Ell. & Sol.) Lamouroux, and if the Japanese plant of Kjellman is different, it must have a new name.

The verification of the Bahaman and the Japanese species would necessitate inspection of both types, and the existence of Ellis and Solander's type of *Corallina fruticulosa* is doubtful. Under such circumstances it seems best to treat these plants from the Pacific waters separately from the West Indian species. In view of this the plants from Clarion Island off the west coast of Mexico are described under a new name. Kjellman's homonymous "*G. fruticulosa*" from Cape Nomo, Japan, as well as Tanaka's *G. fruticulosa* (Japanese plant) and Tseng's from Hongkong and Pratas Island may for the present (pending examination) be considered conspecific.

Specimens studied. — MEXICO: Sulphur Bay, Clarion Island, Revilla Gigedo Islands, Taylor 34-53 (TYPE), Jan., 1934.

Further distribution. — Probably Pratas Island; Hongkong; several localities in Japan.

Galaxaura ramulosa Kjellman. — Pl. II,
Figs. 3-5; Pl. VII, Fig. 1

Kjellman, 1900, pp. 50-51, pl. 3, figs. 24-26, pl. 4, figs. 1-3, pl. 20, fig. 18.

Plants 5-9 cm. high, attached by a discoid holdfast; branches more or less regularly dichotomous, villous; internodes 2-15 mm. long, 0.5-1.2 mm. in diameter; medullary filaments 6-20 μ in diameter, peripheral tissue composed of the supporting and tumid cells of the assimilators; supporting cells well developed, trigonal to polygonal, 30-35 μ high, 20-40 μ in diameter, each bearing one or two assimilatory filaments; tumid basal cells prominent, oval, obovate, or elliptical, 40-65 μ long, 20-40 μ in diameter; short assimilatory filaments two-celled, including basal and terminal cells; terminal cell subglobose, 20-32 μ in diameter, nearly as wide as its basal cell, rarely wider; shaft of extended assimilatory filaments 0.8-1.2 mm. long, 12-15 μ in diameter toward the base, and 18-20 μ above, cells 1-3 times as long as the diameter.

The species is characterized by the two-celled short assimilatory filaments whose terminal cells are nearly the same width as their basal cells.

So far as is known, *G. ramulosa* has not been reported since Kjellman's time; therefore this is the first record for Pacific waters and also the first for regions outside its type locality, Pernambuco, Brazil. I am sure, however, that the plant must have been collected and mistaken for other species of the Subverticillatae.

Type locality. — Pernambuco, Brazil.

Specimens studied. — PANAMA: Jicarita Island, west coast of Panama, Taylor 34-243, 34-505, Feb. 20, 1934.

Further distribution. — East coast of Brazil.

Galaxaura fasciculata Kjellman. — Pl. II,
Fig. 2; Pl. VIII, Fig. 1

Kjellman, 1900, p. 53, pl. 5, figs. 1-9, pl. 20, fig. 14; Weber-van Bosse, 1921, pp. 211-212; Tanaka, 1936, pp. 147-148, figs. 5-6, pl. 34, fig. 3; Tseng, 1941, pp. 86-87, fig. 2.

Plants 5–9 cm. high; fronds terete, villous throughout; branches more or less dichotomous, sometimes quasi-umbellate from being proliferous or closely forking; internodes continuous or subarticulate, 2–20 mm. long, 0.8–1.5 mm. in diameter; extended assimilatory filaments fasciculate, 1–2 mm. long, fascicles evenly distributed; medullary filaments commonly 8–14 μ , rarely up to 24 μ in diameter, peripheral tissue composed of the supporting and tumid basal cells of the assimilators, the former commonly poorly developed or undifferentiated; tumid basal cells of the short assimilators subcylindrical to clavate, 25–50 μ long, 15–22 μ wide, often with lateral branches, therefore fasciculate; terminal cells subglobose or obpyriform, 28–46 μ in diameter; shaft of extended assimilatory filaments simple or rarely branched, 14–16 μ in diameter toward the base, 18–20 μ above.

Plants of this species can be recognized by the fasciculate arrangement of both the extended and the short assimilatory filaments, the characteristic particularly suggested in the specific name. The condition arises from the branching of the tumid basal cells and, so far as is known, is unique in the genus.

Type locality. — Celebes Islands.

Specimens studied. — PHILIPPINE ISLANDS: Culion Island, Calamian Group, *Bartlett* 15582, 15596, July 27, 1935; JAVA: near Baai van Batavia, *Kostermans* 429, Oct. 11, 1938; west cape of Java, *Kostermans* 689, Oct. 18, 1938; TONGA: Mukualofa, *Brooks* in herb. Taylor, 20493, Aug. 27, 1931.

Further distribution. — Japan, Formosa, Hainan, Malay Archipelago.

Galaxaura subverticillata Kjellman. — Pl. II,
Fig. 1; Pl. VII, Fig. 2

Kjellman, 1900, p. 48, pl. 3, figs. 12–14, pl. 20, fig. 17; Børgesen. 1916, p. 92, fig. 97; Taylor, 1928, p. 141, pl. 21, fig. 17, pl. 31, fig. 6; Tanaka, 1936, pp. 146–147, figs. 3–4, pl. 34, fig. 2.

Plants 4–7 cm. high; branches dichotomous, subverticillately villous; internodes 3–10 mm. long, 1.0–1.5 mm. in diameter; extended assimilatory filaments 1 mm. long, forming narrow bands at regular or subregular intervals alternating with wider bands of short assimilatory filaments; medullary filaments 7–28 μ in diameter; the peripheral tissue composed of the supporting and basal

cells of the assimilators; supporting cells less well developed or undifferentiated, rarely trigonal or quadrate; tumid basal cells oval or elliptical, 40–76 μ tall, 25–46 μ wide; short assimilatory filaments commonly three-, rarely two-celled (including tumid basal cell), terminal and subterminal cells smaller than the basal cells; shaft of extended assimilatory filaments simple or sometimes branched above, 15 μ in diameter toward the base, the upper part 20 μ in diameter, cells 1–3 times as long as wide.

This species might easily be confused with *G. subfruticulosa*, but can be differentiated because its extended assimilatory filaments form narrow bands alternating with wider bands composed of short assimilatory filaments. The extended assimilatory filaments in *G. subfruticulosa* and other species of the Subverticillatae may sometimes appear to be subverticillate at the upper part of the branches, but these are usually not distinct and are wider than the short assimilatory bands. In other words, the development of extended assimilatory filaments in *G. subfruticulosa* exceeds that of the short assimilatory filaments, whereas in *G. subverticillata* the reverse is true. Furthermore, the short assimilatory filaments in *G. subverticillata* are commonly three-celled, with terminal and subterminal cells distinctly smaller than the tumid basal cell.

Type locality. — St. Croix, Virgin Islands.

Specimens studied. — PHILIPPINE ISLANDS: Puerto Galera Bay, Mindoro Prov., Bartlett 13787, May 12–17, 1935; Lubang Island, Mindoro Prov., Villaflora 7–8, Aug. 24, 1935; 47, Sept. 11–17, 1935.

Further distribution. — Bermuda, Florida, West Indies, Japan, East Indies.

Galaxaura robusta Kjellman. — Pl. III,

Figs. 1–10; Pl. IX, Fig. 2

Kjellman, 1900, p. 85, pl. 18, figs. 19–22, pl. 20, fig. 42. Tanaka, 1936, pp. 170–171, pl. 45, figs. 38–39.

Plants up to 10 cm. high, with robust regularly dichotomous branches; basal attachment not seen; thallus cylindrical, becoming flattened when dried, thin, fragile after decalcification; segments plicate, constricted, or subarticulate at the nodes, 0.8–2.0 cm. long, 4 mm. in diameter; medullary filaments commonly 16 μ in diameter, ranging between 8 and 20 μ , the majority of them lying close to the periphery; cortical parenchyma monostromatic, cells large, sub-

globose or rectangular in section, 40–50 μ tall, 75–90 μ broad, each bearing 1–3 cylindrical stalk cells, 15–20 μ tall, 8–11 μ in diameter; terminal cells obconical, 16–18 μ tall, 30–40 μ broad at the outer wall, containing large stellate chromatophores with a pyrenoid at the center, cells closely arranged, angular in surface view, forming a layer of epidermis; tetrasporangia soriferous, clavate or obpyriform, 40–60 μ long, 25–30 μ in diameter at the upper end; spores tetrapartite, reniform or amygdaliform, 20–25 μ long, median diameter 10–12 μ .

The species is known to have branches coarser than those of any cylindrical asexual *Galaxaurae* hitherto described. Since this specimen from Tonga agrees in every noteworthy respect with the description and the illustrations given by Kjellman, it is easily referred to *G. robusta*.

Being an asexual member of the Robustae the species may pair, as suggested by Howe (1916), to complete a life cycle with one of the members of the Umbellatae. One may mention in this connection that there is a sexual specimen (*Bartlett 15022*) from Dalupiri Island, Philippines, which also has very coarse branches, although not quite so robust as those of the Tonga plant, which in many respects would fit the requirements for the sexual phase of *G. robusta*. The Philippine plant which I have called *G. umbellata* (Esp.) Lamouroux will be considered with the sexual plants in Part II.

Type locality. — Nossi Bé Island, Madagascar.

Specimens studied. — TONGA: Mukualofa, Brooks, in herb. Taylor, 20444, Aug. 27, 1931.

Further distribution. — Nossi Bé Island, Malay Archipelago, Formosa, Japan.

Galaxaura barbata, sp. nov. — Pl. IV,

Figs. 1–7; Pl. VI, Fig. 2

Plantae 5 cm. altae, ad substratum disco adfixae; ramis teretibus, siccitate ad apicem interdum compressis; plus minusve regulariter dichotomis, barbatis cum filamentis assimilatoriis divergentibus annulos angustos approximatos vel remotos formantibus, segmentis constrictis vel subarticulatis, 3–9 mm. longis, diam. 0.5–1.0 mm.; filamentis medulariis plerumque diam. 12–16 μ , sed inter 6 et 20 μ variantibus; cortice monostromatico, cellulis corticalibus grandibus,

ovoideis vel subglobosis, 32–50 μ diam., cellulas 1 vel 2 subcylindricas vel clavatas stipitiformes ferentibus, simplices vel furcatas; cellulis stipitiformibus aut cellulam singulam terminalem ferentibus aut si furcatis cellulas duas terminales subglobosas vel ovoideas vel clavatas, 28–44 μ altas, 20–28 μ diam., confertis, inter se compressis angulatisque, aspectu superficiali ut cohaerentibus; filamentis assimilatoriis divaricatis 1–2 mm. longis, 16–18 μ diam.; cellulis basalibus tumidis magnis, 90–120 μ longis, 28–40 μ diam., saepe granula amylacea includentibus. Specimen typicum legit W. R. Taylor, no. 34–364, ad Insulam Sanctae Mariae, Galapagos Ins., Jan. 27, 1934.

Plants 5 cm. high, attached to the substratum by a discoid holdfast; branches terete, apex sometimes compressed when dried, more or less regularly dichotomous, barbate with extended assimilatory filaments which form narrow rings with close or remote intervals; segments constricted or subarticulate, 3–9 mm. long, 0.5–1.0 mm. in diameter; the medullary filaments commonly 12–16 μ , ranging from 6 to 20 μ in diameter; cortical tissue monostromatic, cells large, ovate or subglobose, 32–50 μ in diameter, each bearing 1–2 clavate stalk cells, 12–24 μ long, 10–18 μ in diameter, simply bearing one terminal cell or slightly furcate at the distal end and bearing two; terminal cells subglobose, oval or clavate, 28–44 μ tall, 20–28 μ in diameter, much crowded, angular in surface view, appearing coherent with adjacent cells; the extended assimilatory filaments 1–2 mm. long, 16–18 μ in diameter, shaft cells cylindrical, 1–5 times as long as diameter; tumid basal cells very large, 90–120 μ long, 28–40 μ in diameter, often containing starch grains.

The species is a deep-water representative, dredged from a depth of 37 meters. It shows the characters of "Teretes" in habit but of Arboreae in structure. Phylogenetically it will probably find its nearest affinity in Kjellman's *G. lenta* from Ceylon Island, which likewise has terete branches throughout, whereas other species of the Arboreae all have flattened branches above. Furthermore, the strong development of the extended assimilatory filaments which occur in narrow rings at the lower parts of the branches and at the base of the proliferations distinguishes the present species from the glabrous or subglabrous *G. lenta*. The new species is also distinguished by having very large tumid basal cells, which are between 90 and 120 μ long and 28 and 40 μ in diameter. These measurements are, in fact, the greatest in all the plants I have examined.

These two species of terete *Arboreae* may bridge the gap between the *Subverticillatae* and the *Arboreae*. No definite conclusion can be drawn, however, until the life cycle of these algae becomes better known.

I was inclined to interpret the first specimen I saw as a juvenile stage of one of the *Arboreae* species, probably of *G. arborea*, the basal parts of whose branches are subterete and often villous, with rings of extended assimilatory filaments. Later, when a second specimen, collected by Schmitt from the Island of Santa Cruz, in December, 1934, came under my observation, the existence of another species became quite clear, and it is here recognized under a new name.

Specimens studied. — ECUADOR: Santa Maria Island, Galápagos Islands, Taylor 34-364 (TYPE), Jan. 27, 1934; Island of Santa Cruz, Schmitt 316-335, Dec. 8, 1934.

Further distribution. — So far as is known, it is endemic in the Galápagos Islands.

Galaxaura stupicaulis Kjellman.¹ — Pl. V,
Figs. 10-12; Pl. XI, Fig. 1

Kjellman, 1900, pp. 75-76, pl. 14, figs. 1-9, pl. 20, fig. 28.

Plants 6-7 cm. high, attached by a discoid holdfast; branches terete, villous below, flattened above, continuous, or proliferous with subarticulate constrictions, each encircled by a tuft of extended assimilatory filaments; segments 2-7 mm. long, 1-2 mm. wide, carnose-membranous, margins slightly thickened; the medullary filaments 7-15 μ in diameter; cortex parenchymatous, 1-2-stromatic, commonly 20-40 μ , rarely to 60 μ thick (excluding the stalk and the terminal cells), the inner cells large, subglobose or compressed, 20-44 μ tall, 25-50 μ broad, outer cells smaller, subglobose or pyriform, bearing 1-2 stalk cells; stalk cells cylindrical or cuneate-cylindrical, simple or once furcate, unicellular, rarely two-celled, 30-36 μ tall; terminal cells variable, subglobose, oval or clavate, 20-44 μ tall, 20-32 μ in diameter; extended assimilatory filaments 1 mm. long, with one or two tumid basal cells, size 58-76 μ long, 24-34 μ in diameter; shaft 15-16 μ in diameter, cells 2-5 times as long as the diameter.

¹ This name was published by Kjellman as *G. stupocaulon*, which, for the sake of correctness, should be modified to *G. stupicaulis*, since the adjective must agree with the generic name in gender.

In the group of Fruticulosae Kjellman named two species from Brazil, primarily on the basis of morphological differences: *G. frutescens*, characterized by not having decompound proliferations, the internodes 2-3 mm. wide, inconspicuously zonate, the margins not thickened; and *G. stupicaulis*, differentiated by having decompound proliferations, the internodes hardly over 2 mm. wide, distinctly transverse-zonate, and the margins thickened.

The distinctions regarded by Kjellman as specifically important could very easily be fluctuating variations only, and thus bear no taxonomic significance. In the discussion of *G. arborea* I mention that, because of the frequent occurrence of the verticillate-extended assimilatory filaments on these plants and on the Philippine plants, *Barlett 15009A*, I am tempted to consider the present Costa Rican plants the same as the Philippine *G. arborea*, although the former are more proliferous.

The plants from Costa Rica were collected from intertidal rocks — a zone where plants are constantly subject to tidal and wave action and to periodic exposure; thus growth may not be normal and continuous. Such conditions may account for some of the specimens being extremely proliferous. However, since none of these differences have been tested by collectors in the field, I have, at least for the time being, decided to maintain Kjellman's *G. stupicaulis* and to refer the Philippine plants to *G. arborea*.

Among the collections there are some sexual plants accompanying the asexual ones, which are very probably the sexual phase of the same species. Because of my present treatment of the species these sexual plants are tentatively assigned to the species *G. veprecula*.

Type locality. — Bahia, Brazil.

Type specimen. — In Areschoug's herbarium, under the name *G. marginata*.

Specimens studied. — COSTA RICA: Golfo Dulce, *Taylor 39-90A*, 39-91A, March 26, 1939.

Further distribution. — Bahia, Brazil.

Galaxaura arborea Kjellman. — Pl. V,
Figs. 1-5; Pl. X, Figs. 1-2

Kjellman, 1900, pp. 72-73, pl. 11, figs. 1-11, pl. 20, fig. 39. Tanaka, 1936, pp. 161-162, figs. 24-25, pl. 40; Tseng, 1941, pp. 94-95, fig. 6.

Plants densely bushy, deliquescent-arborescent, as much as 12 cm. high, attached by a broad, matlike or discoid holdfast; caudex and basal part of branches subterete, villous with rings of extended assimilatory filaments, sometimes subglabrous, above flattened, glabrous, carnose-membranous, continuous or proliferous, base of proliferations encircled by a tuft of extended assimilatory filaments; thallus 1-2 mm. broad, margins thickened, often with distinct transverse striations, at least toward the distal parts of branches; segments elongate-cuneate, 3-10 mm. long, 1.5-2.5 mm. wide; medullary filaments 8-16 μ in diameter, the cortical parenchyma tissue 20-60 μ thick, 1-2-stromatic, cells subglobose or compressed, 16-60 μ radially, 40-60 μ tangentially, each bearing 1-2 cuneate-cylindrical stalk cells, 18-25 μ tall, upper end simple or slightly furcate, 12-18 μ in diameter, lower 8-12 μ ; terminal cells ovate or clavate, 22-36 μ tall, 18-25 μ in diameter, loosely arranged, appearing subglobose on the surface; extended assimilatory filaments 0.5-1.5 mm. long; tumid basal cells 1-2, size 50-70 μ long, 24-40 μ in diameter; shaft cells 18-20 μ in diameter, 2-4 times as long as broad.

The distinction between the Pacific *G. arborea* and the West Indian *G. frutescens* is so trivial that I often doubted the value of separation. In the Philippine collection plants under *Bartlett 15009A* agree very closely with Kjellman's description of *G. frutescens*, whereas his plants under *14608*, collected from the same locality but earlier in the season, showed vigorous growth and arborescent habit. At first I was tempted to call the former *G. frutescens* and the latter *G. arborea*, but since they all came from the same locality the minor external differences were treated as seasonal variations, and the plants were considered identical.

Type locality. — Australia.

Type specimen. — In J. C. Agardh's herbarium, under the name *Galaxaura marginata*.

Specimens studied. — PHILIPPINE ISLANDS: Dalupiri Island, Babuyan, *Bartlett 14608*, July 17; *15009A*, Oct. 5, 1935.

Further distribution. — Japan, Hongkong, Hainan Island, Australia, Hawaiian Islands.

Galaxaura apiculata Kjellman. — Pl. V,

Figs. 13-19; Pl. IX, Fig. 1

Kjellman, 1900, pp. 74-75, pl. 12, figs. 13-26, p. 20, fig. 36; Tanaka, 1936, pp. 162-163, figs. 26-27, pl. 41, fig. 2.

Plants 8-9 cm. high (basal attachment not seen); branches flabellate, flattened, decompound-furcate, angles obtuse or round, often subtending 70° - 90° ; segments 5-12 mm. long, margins thickened; proliferations few, their bases encircled by tufts of extended assimilatory filaments; medullary filaments 8-12 μ , rarely 16-20 μ in diameter; cortical parenchyma monostromatic, cells large, subglobose or compressed, each bearing 1-2 cylindrical or cuneate-cylindrical stalk cells, 18-25 μ tall; terminal cells subglobose, oval or obpyriform, 40-50 μ tall, 40-44 μ in diameter, distal end wall apiculate; apiculi 2 μ tall, in older cells often attaining a sublateral position, thus not easily seen; extended assimilatory filaments 0.5-1.5 mm. long, 25-40 μ broad; shaft 12-15 μ in diameter, cells 3-4 times as long as the diameter.

The species is characterized by having mucronate terminal cells — a specific character established by Kjellman to distinguish the Japanese plant from *G. marginata* of the West Indies. This characteristic, however, has been questioned by Børgesen, who says that the numerous specimens he collected in the Danish West Indies agree in all essentials with Kjellman's description of the Pacific plants, except that the terminal cells of the West Indian plants end commonly, but not always, in a short apiculus. My observation of the West Indian *G. marginata* did not quite agree with Børgesen's, for in only two specimens, one from Bermuda, the other from the West Indies, did I detect a few sporadic mucronate cells, with apiculi not so tall as those of the Philippine and the Tonga plants.

The terminal cells of the Tonga plant have a slightly smaller diameter than those of the Philippine plants, but since both specimens show apiculate terminal cells they are treated as identical.

Since both specimens lack basal attachment, it is impossible to tell whether the plants are arborescent or frutescent. The Philippine plants were recorded as "cast up by waves," so that it is quite possible that they represent only parts of a plant broken off from the basal attachment, and might easily be caulescent, and thus agree in habit with Kjellman's *G. apiculata* from Japan.

Type locality. — Pacific Ocean near Japan.

Specimens studied. — PHILIPPINES: Puerto Galera Bay, Mindoro Island, Bartlett 18782, May 12-17, 1935; TONGA: Mukualofa, Brooks in herb. Taylor, 25494, Aug. 27, 1931.

Further distribution. — Japan.

Galaxaura spathulata Kjellman. — Pl. V,
Figs. 6–9; Pl. XI, Fig. 2

Kjellman, 1900, p. 74, pl. 12, figs. 5–12, pl. 20, fig. 35.

Plants to 18 cm. or more high, subcaulescent; caudex villous, warty, 3–4 cm. long, 4–6 mm. thick; branching dichotomous, angles acute, branches flattened, carnose- or subcoriaceous-membranous, continuous, rarely proliferous; segments 0.5–1.5 cm. long, upper end 1.5–3.0 mm., the lower 0.5–1.5 mm. in diameter, inconspicuously transversely striate, margins slightly thickened, tomentose when injured; apex of branches round, spathulate, or subfalcate; medullary filaments in the caudex 8–32 μ in diameter, peripheral filaments assimilatory or rhizoidal, with well-developed tumid basal cells forming cortical tissue; cortical parenchyma tissue 1–3-stromatic, 60–80 μ thick, the innermost cells largest, globose or compressed, 24–60 μ tall, 60–80 μ broad, the outer cells ovate or obpyriform, each bearing 1–2 cuneate-cylindrical, simple or once-furcate stalk cells, 20–32 μ long; terminal cells variable, subglobose, oval, or obpyriform, 30–44 μ tall, 25–30 μ in diameter, much crowded, in surface view angular; extended assimilatory filaments 1.0–1.5 mm. long, with one or two tumid basal cells, 70–90 μ long, 30–40 μ in diameter; shaft 20 μ in diameter, cells 2–4 times as long as thick; marginal tomentum similar to young extended assimilatory filaments, cells shorter, 1–2 times as long as the diameter.

In habit these plants from Ecuador resemble in some respect each of the Pacific Arboreae described by Kjellman, and thus difficulty is encountered in identifying the species. Kjellman's specific recognition of these plants was primarily based on their general growth habit and the superficial forms of the branch tips — characters which may not be reliable for specific separation unless supported by structural features.

Perhaps I should call these Ecuadorian plants *G. arborea* instead of *G. spathulata* because they resemble both species in certain respects, and if future study should prove the species identical the former name would be valid because of priority. However, since the plants are tall like those of *G. spathulata* and since in habit they do not resemble *G. arborea* of the Philippine Islands, they are tentatively assigned to *G. spathulata*.

The collection includes a sexual plant which is likewise tall and

arborescent, resembling the asexual plant of *G. spathulata*. It may represent the sexual phase of *G. spathulata*, but is tentatively ascribed to the section *Angustifrondes* because of its smooth branches, whose epidermal cells are free from spinulose outgrowths.

Type locality. — Freemantle, Australia.

Type specimen. — In Areschoug's herbarium, under the name *Microthoë marginata* Decaisne.

Specimens studied. — ECUADOR: Isabela Island, Taylor 34-164, Jan. 13, 1934; Santa Maria Island, Galápagos Islands, Taylor 34-246, Jan. 17-18, 1934.

Further distribution. — Australia.

SUPPLEMENTARY NOTE

The species *Galaxaura barbata* is closely related to *G. paschalis* Børgesen from Easter Island. (See F. Børgesen, "Marine Algae from Easter Island," in C. Skottsberg, *The Natural History of Juan Fernandez and Easter Island*, Vol. II, Part III, pp. 247-309, 50 figs. Uppsala, 1924; preprint dated 1920 on back cover.) Børgesen's species is likewise characterized by having cylindrical branches with well-developed whorls of hairs, but *G. barbata* differs from it in several respects. The terminal cells of the short assimilatory filaments of *G. barbata* are ovate or subglobose, and the cortical cells are well developed, forming a monostromatic layer of parenchymatous tissue, whereas the terminal cells in *G. paschalis* are two or three times as long as wide, and the cortical cells are either poorly developed or undifferentiated. The tumid basal cells of the extended assimilatory filaments in *G. barbata* are very large and prominent, and the corresponding cells as described by Børgesen are little differentiated. Unfortunately, Skottsberg's work escaped my notice until the present paper was in type, since Børgesen's species had not been referred to in the sources usually consulted. To judge from the description only (for I have not seen material from Easter Island), *G. paschalis* would key out to *G. barbata*, from which it should be easily distinguished by the contrasting characteristics here pointed out.

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EXPLANATION OF PLATE I

Galaxaura filamentosa

FIG. 1. Section of portion of thallus. $\times 140$

FIG. 2. Young extended assimilatory filament. $\times 225$

FIGS. 3-4. Medullary filaments containing starch grains. $\times 225$

FIG. 5. Mature extended assimilatory filaments, showing branching. $\times 225$

FIG. 6. Extended assimilatory filaments with undifferentiated or poorly developed supporting cells. $\times 225$



Galaxaura filamentosa

EXPLANATION OF PLATE II

Galaxaura subverticillata

FIG. 1. Section of portion of thallus. $\times 195$

G. fasciculata

FIG. 2. Section of portion of thallus, showing fasciculate short assimilatory filaments. $\times 195$

G. ramulosa

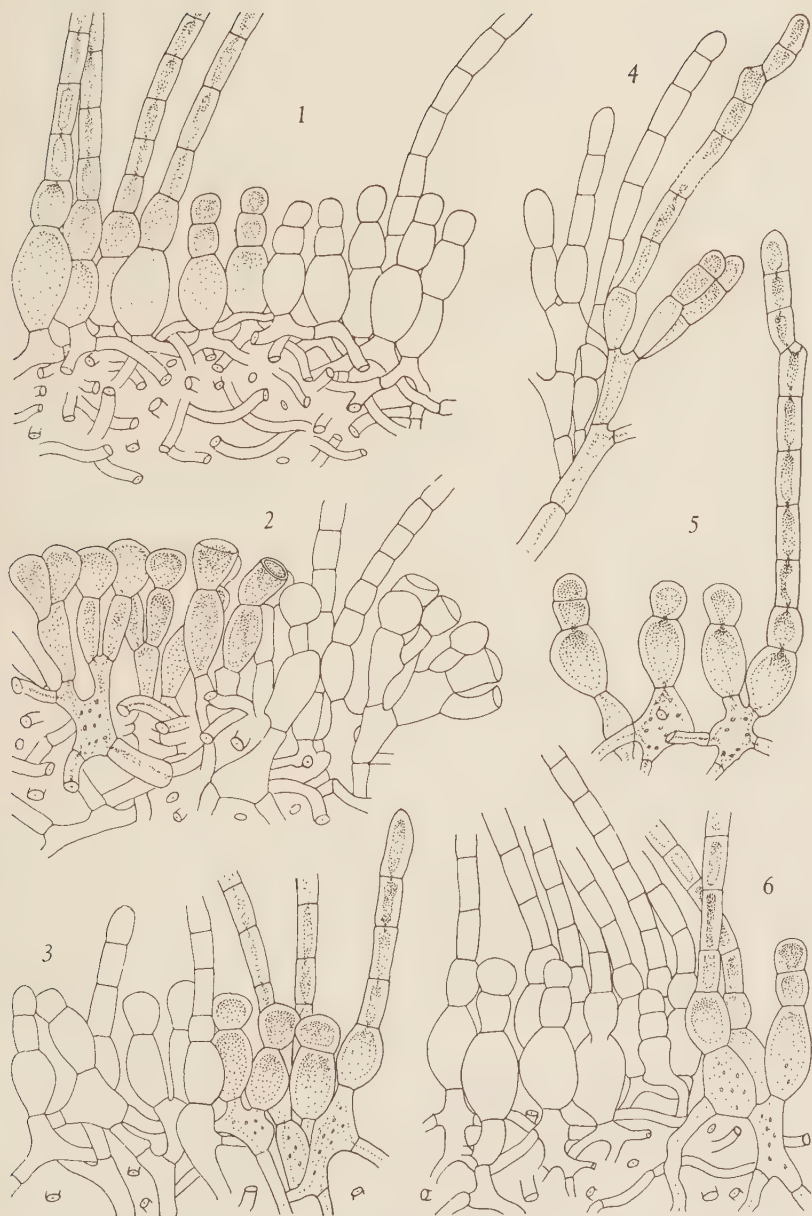
FIG. 3. Section of portion of thallus. $\times 195$

FIG. 4. Various stages of extended assimilatory filaments. $\times 195$

FIG. 5. Short and extended assimilatory filaments borne separately or by a common supporting cell. $\times 195$

G. subfruticulosa

FIG. 6. Section of portion of thallus. $\times 195$

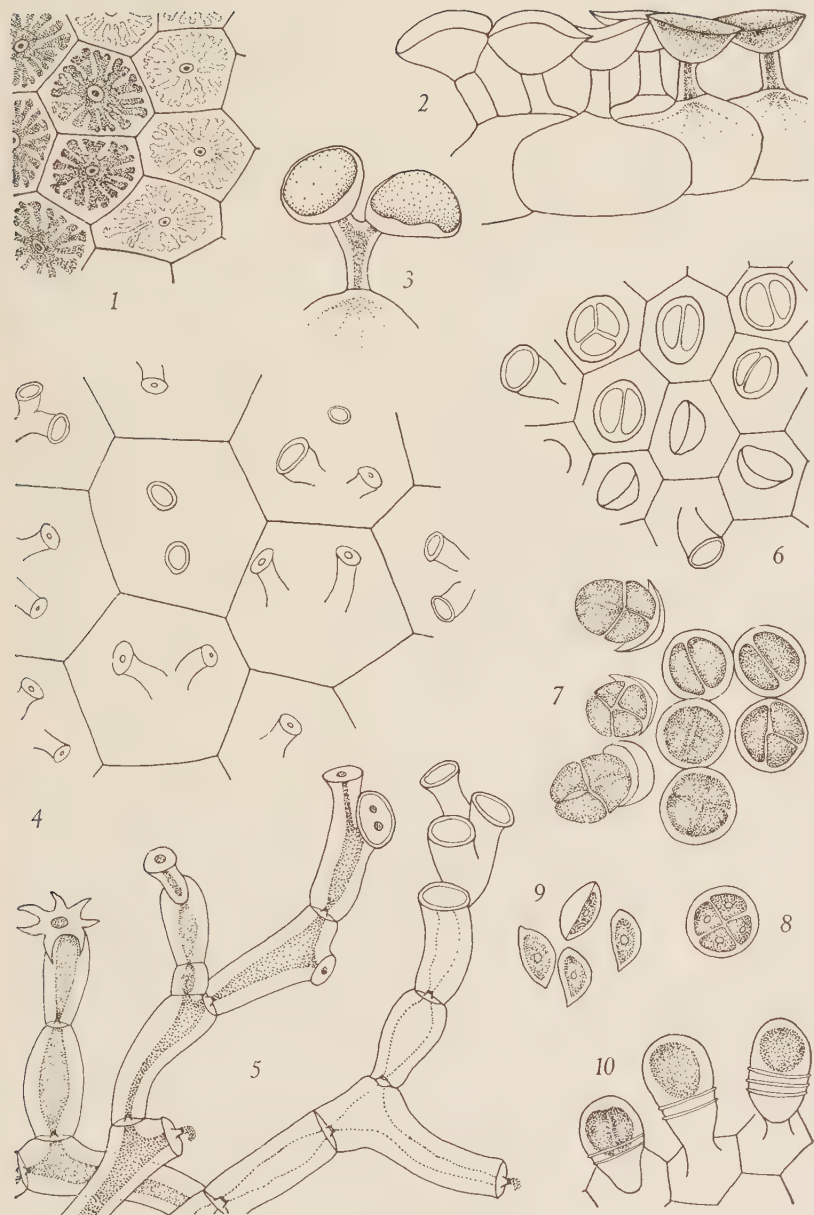


Galaxaura species

EXPLANATION OF PLATE III

Galaxaura robusta

- FIG. 1. Surface of thallus, showing terminal cells with large stellate chromatophores. $\times 340$
- FIG. 2. Section of thallus, showing assimilators and cortical cells. $\times 340$
- FIG. 3. Single cortical cell, with bifurcate stalk cell bearing two terminal cells. $\times 340$
- FIG. 4. Cortical cells, exterior view, showing stalk cells after terminal cells become detached. $\times 340$
- FIG. 5. Medullary filaments near periphery bearing cortical cells at the ends. $\times 340$
- FIG. 6. Sorus, surface view. $\times 340$
- FIG. 7. Sporangia, showing cleavage of spore mother cells. $\times 340$
- FIG. 8. Mature sporangium with tetrads. $\times 340$
- FIG. 9. Mature spores. $\times 340$
- FIG. 10. Sporangia, lateral view, showing regeneration within old sporangium walls. $\times 340$



Galaxaura robusta

EXPLANATION OF PLATE IV

Galaxaura barbata

- FIG. 1. Habit of portion of plant, showing barbate extended assimilatory filaments. $\times 1.5$
- FIG. 2. Section of portion of thallus. $\times 340$
- FIG. 3. Surface of thallus. $\times 340$
- FIG. 4. Section of portion of young thallus. $\times 340$
- FIG. 5. Young extended assimilatory filament. $\times 340$
- FIG. 6. Apical part of extended assimilatory filament. $\times 340$
- FIG. 7. Basal part of extended assimilatory filament, showing large tumid basal cells. $\times 340$



Galaxaura barbata

EXPLANATION OF PLATE V

Galaxaura arborea

FIG. 1-2. Section of portion of thallus, showing cortical cells and assimilators. $\times 225$

FIG. 3. Interior surface view of cortical cells, showing connection with medullary filaments. $\times 150$

FIG. 4. Young assimilators at apical parts of branches. $\times 225$

FIG. 5. Extended assimilatory filaments at base of proliferations. $\times 160$

G. stupicaulis

FIG. 6-8. Young assimilators, showing connections with medullary filaments. $\times 225$

FIG. 9. Section of portion of thallus. $\times 225$

G. spathulata

FIG. 10. Short assimilators. $\times 225$

FIG. 11-12. Section of portion of thallus, showing cortical tissue and assimilators. $\times 225$

G. apiculata

FIG. 13. Terminal cells without apiculi. $\times 225$

FIG. 14. Young assimilators, with apiculate terminal cells. $\times 225$

FIG. 15. Old assimilators. $\times 225$

FIG. 16. Assimilators, surface view. $\times 225$

FIG. 17. Extended assimilatory filaments from base of proliferations. $\times 150$

FIG. 18. Inner cortical cell in connection with medullary filament. $\times 225$

FIG. 19. Section of portion of thallus. $\times 225$

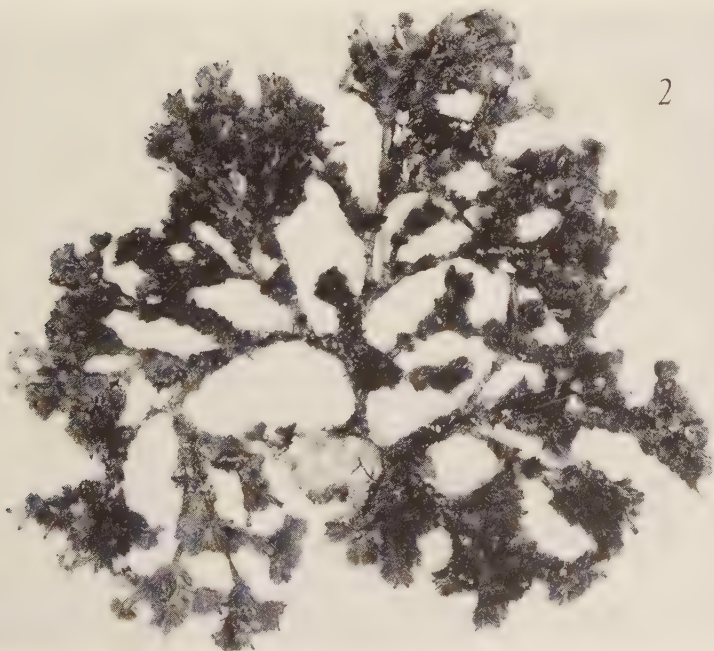


Galaxaura species

EXPLANATION OF PLATE VI

FIG. 1. *Galazaura filamentosa*, sp. nov.; type specimen. $\times 1$

FIG. 2. *G. barbata*, sp. nov.; type specimen. $\times 1.5$

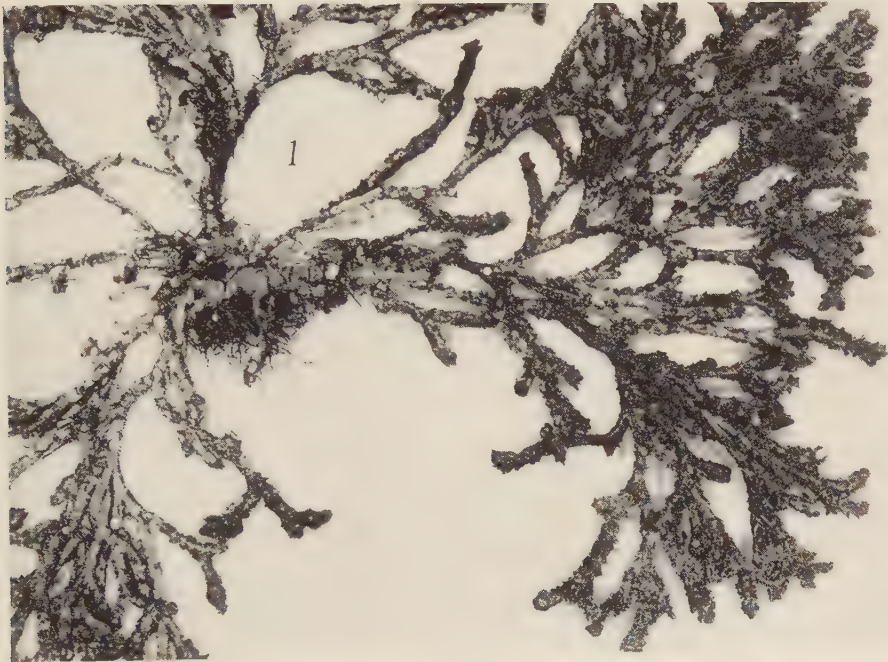


Galaxaura species

EXPLANATION OF PLATE VII

FIG. 1. *Galaxaura ramulosa*; Taylor no. 34-505, Jicarita Island, Panama. $\times 1.4$

FIG. 2. *G. subverticillata*; Villaflores no. 7A, Mindoro, Philippines. $\times 2.2$

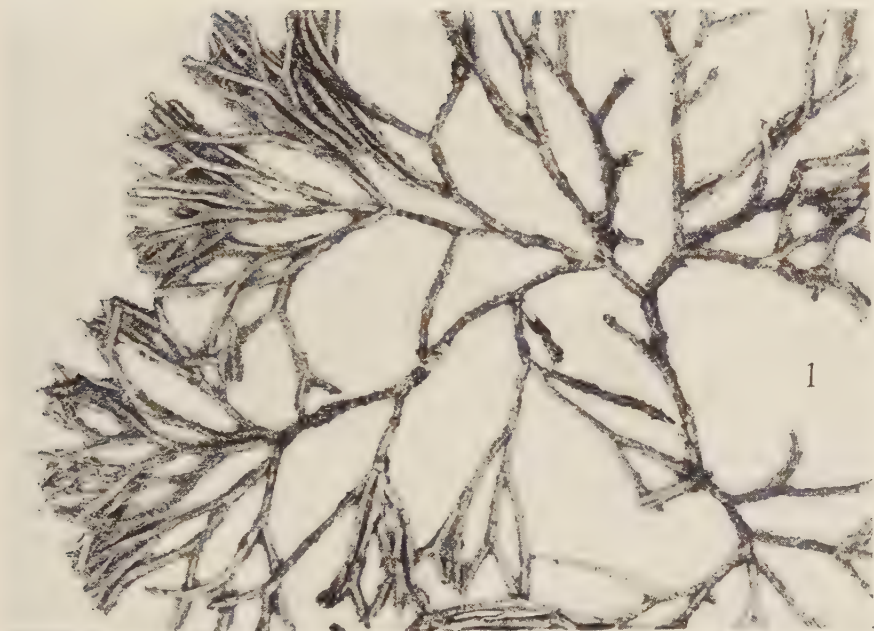


Galaxaura species

EXPLANATION OF PLATE VIII

FIG. 1. *Galaxaura fasciculata*; Kostermans no. 429, Java. $\times 1.2$

FIG. 2. *G. subfruticulosa*, sp. nov.; type specimen. $\times 1.3$



Galaxaura species

EXPLANATION OF PLATE IX

FIG. 1. *Galaxaura apiculata*; Brooks in Taylor's herb. no. 20494, Mukualofa, Tonga. $\times 0.9$

FIG. 2. *G. robusta*; Brooks in Taylor's herb. no. 20444, Mukualofa, Tonga. $\times 0.8$

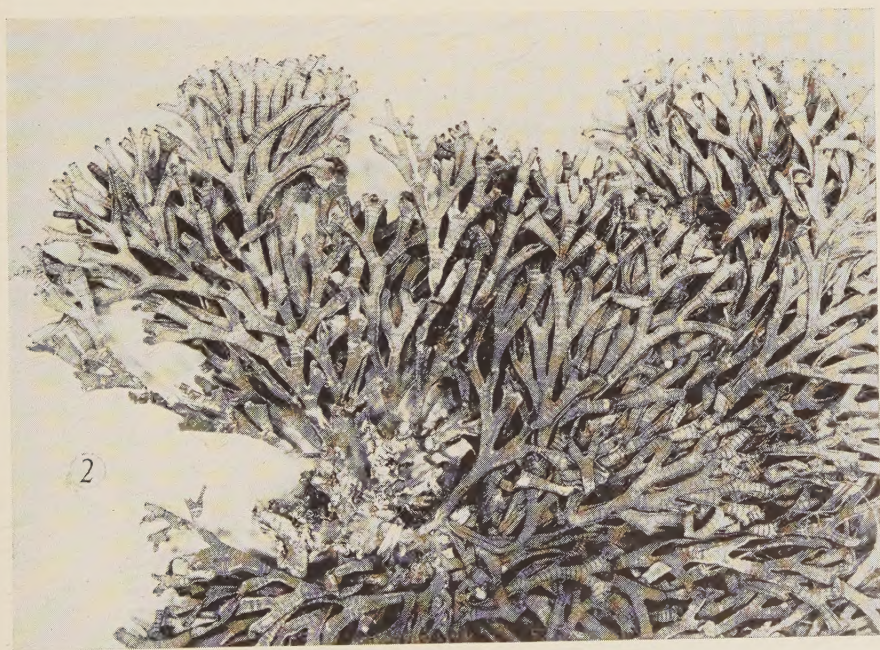
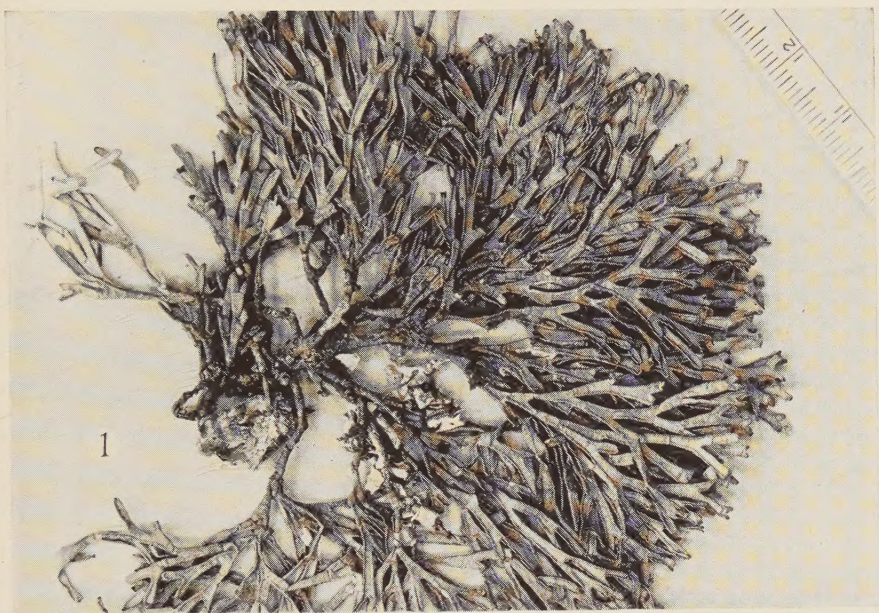


Galaxaura species

EXPLANATION OF PLATE X

FIG. 1. *Galaxaura arborea*; Bartlett no. 15009A, Dalupiri Island, Philippines.
× 1

FIG. 2. *G. arborea*; Bartlett no. 14608, Dalupiri Island, Philippines. × 1.1



Galaxaura species

EXPLANATION OF PLATE XI

- FIG. 1. *Galaxaura stupicaulis*; Taylor no. 39-90A, Golfo Dulce, Costa Rica.
× 1.5
- FIG. 2. *G. spathulata*; Taylor no. 34-164, Isabela Island, Galápagos Islands.
× 0.5



Galaxaura species

